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ABSTRACT

The need for higher education to plan curricula based upon generalizable human, analytical, and technical skills is discussed in view of historical and economic changes, productivity questions, demographic projections, and employment forecasts. Questions are posed regarding the form of undergraduate education that will best prepare the college graduate for employment in a society marked by high technology and automation and characterized by a more impersonalized, highly efficient work and nonwork environment. The following factors are credited as affecting the implementation of automated equipment and robotics: productivity rates, manpower supply, preparation of manpower, cost of physical capital, cost of human capital, and the state of the art of the technologies. It is concluded that the education of the 1980s, 1990s, and the 21st century must prepare the graduate for growth, adaptability, and further learning. Students must be prepared to be skilled in analysis and problem solving. The new technologies will require a higher level of verbal and mathematical literacy to work in the processing of information. Higher education in the future should contain essential elements for on-the-job scientific and technical training. (SW)

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Impact of the "Steel Collar" Revolution and Robotics upon Higher Education

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THE ASSOCIATION FOR INSTITUTIONAL RESEARCH

This paper was presented at the Twenty-Third Annual Forum of the Association for Institutional Research held at the Sheraton Centre in Toronto, Ontario, May 23-26, 1983. This paper was reviewed by the AIR Forum Publications Committee and was judged to be of high quality and of interest to others concerned with the research of higher education. It has therefore been selected to be included in the ERIC Collection of Forum papers.

D. R. Coleman, Chairman
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Abstract

In an effort to increase worker productivity and improve the national economy, business and industry will invest heavily in high technology, automated systems, and robots. Substantial investments will be made in human capital. With business and industry already a major investor in education and training of employees, what is the future role of higher education? This paper discusses the need for higher education to plan curricula based upon generalizable human, analytical, and technical skills. Higher education must prepare the student with skills and attitudes to learn on the job and to achieve human fulfillment in a more impersonalized, highly efficient work and non-work environments.

Introduction

In the last forty years, higher education has been responsive to the needs of American society. When the G.I.s returned from the wars, higher education met their needs. With the launching of Sputnik, American higher education was galvanized into increasing the scientific capability of the nation. Today, the American economy is again turning to higher education for help.

In an effort to increase work productivity and to compete effectively, U. S. business and industry is investing heavily in robotics and other automated forms of production. Higher education will be called upon to provide research and development support in these new technologies. High technology will replace agriculture and manufacturing and become the focus of university research.

The ultimate concern of this paper is not the university's role in "R&D" but in undergraduate education. What form (or forms) of undergraduate education will best prepare the graduate for employment in a society marked by high technology, automation, efficiency, and depersonalized work environments?

White- and blue-collar workers will come face to face with steel-collar substitutes. Economic investments in the transformation of work in America will lead to the demise of the present day blue-collar worker, many of the office jobs, and a significant part of the white-collar professional sector. New occupations--yet undetermined and unspecified--will arise; new social arrange-

ments in the work place will be established. Higher education in the 1980s must adapt itself to this future. The question is--how should higher education respond? Will higher education just react or will it plan for its future and preserve the critical elements of an undergraduate education?

How can college prepare students for rapid business and industrial change? Should curricula be more or less technical, more or less general and liberal? This discussion is an attempt to get at tentative answers by examining historical and economic changes, productivity questions, demographic projections, employment forecasts, and probable education/training solutions.

The Economic Revolution

You may have heard the story of the doctor, the engineer, and the economist who were arguing about which profession was the oldest. The doctor insisted it was medicine because God created woman by taking a rib from Adam's side. The engineer countered that it was engineering because God created order out of chaos. "Aha!" shouted the economist, "but who do you think created the chaos?"

Economics is changing the ways we think about work and education. Work and education are being shaped by the forces of productivity, demographics, and a short-term quest for viability. Economics and the economic revolution broke the spell of innocence and certainty and plunged man into a chaotic state. Up through the Reformation, the affairs of state and practical men dealt with political, social, and religious matters. The tradi-

tional and class roles of serf and lord provided work, order, and security. The universities at Bologna and Paris did not worry about FTEs (full-time equivalents) and career planning for a changing society. Coincidentally with the beginning of the American Revolution in 1776, Adam Smith published his revolutionary Inquiry into the Nature and Causes of the Wealth of Nations. Henceforth, the pastoral images of land and labor, academe and education, would become the economic devices of land, labor, and capital for economic gain. People would need jobs. Higher education has more and more been seen in economic and employment terms.

The economic revolution brought to the forefront economic gain and productivity as first principles of modern life. These principles will propel us into the use of automation and robotics as they propelled our forefathers into the industrial revolution. With the advent of rapid technological development and implementation in robotics and automation, the roles of the worker and the educator may be further limited.

The challenges of reducing unemployment and social betterment will be the manifest dilemmas of advancing technology and higher education. Social betterment must be the desired end of both economics and education. Social betterment must have as its central concern "the human use of human beings" and concern for the total person. For perspective, let us look back to the industrial revolution.

The Industrial Revolution

The industrial revolution brought positive expectation

and anxiety to the prospect of industrial change. In 1853, an article in the United States Review proclaimed that--

> Machinery will perform all work--automata will direct them. The only task of the human race will be to make love, study, and be happy (Scott and Bolz, 1969).

Now, 150 years later, we still await the prophecy of machines and automata, but today the vision could materialize within this century. In a society with democratic principles, such a prophecy should accrue to all of the breadwinners. But--the healthy skepticism of Ralph Waldo Emerson (1856) is as appropriate today as in the 1850s.

> But a man must keep an eye on his servants, if he would not have them rule him. Man is a shrewd inventor and is ever taking the hint of a new machine from his own structure, adopting some secret of his own anatomy in iron, wood, and leather to some required function in the work of the world. But it is found that the machine unmans the user. What he gains in making cloth, he loses in general power. There should be a temperance in making cloth, as well as in eating. A man should not be a silkworm, nor a nation a tent of caterpillars.

The industrial revolution in America was accompanied by a

national higher education policy. The Morrill Act of 1862 led to the establishment and development of major campuses used to support economic diversification and growth. With or without a new Morrill Act for the 1980s, higher education must prepare graduates for productive and satisfying roles in a high technology society, but higher education should heed the sentiments of Emerson.

The impact of automation and robotics has not yet hit American industry, the worker, or higher education with its full force. Forces that in the past retarded the implementation of automated equipment are being removed, and accelerators are taking their places. Let us discuss the major factors that affect implementation. They are productivity rates, supply of manpower, the preparation of manpower, cost of physical capital, cost of human capital, and the state of the art of the technologies.

Productivity

The economist, Moses Abramovitz, found evidence that per capita output increased more than 400 per cent between 1869-73 and 1944-53, whereas the stock of physical capital increased only by an estimated three-fold (Abramovitz, 1956). He attributed the residual growth in productivity to the contribution of human capital formation. The contribution of human capital to growth and productivity has been supported by studies conducted by Theodore W. Schultz (1962), Edward F. Dennison (1962), and others.

The United States has been on a productivity binge since

the Civil War. The westward expansion, the flood of immigration, the political climate, and the agricultural and industrial development of the country positioned America to be the strongest economic nation in the world. The United States' annual growth rate for almost a hundred years was marginally higher--a percentage point give or take--than the world's leading economic powers. Slow progress enabled the United States to outproduce Germany, France, the United Kingdom, and others.

This supremacy began to erode significantly in the 1960s. As charted in Figure 1, the annual increases in productivity that marked a strong United States economy have been slipping dramatically. In the last decade the slippage in United States productivity is in sharp contrast to Japan's 7% and France's and West Germany's 5% annual rates of labor productivity in the manufacturing sector (Economic Report of the President, 1982).

Insert Figure 1 about here

Physical Capital

Investment in physical capital--stock in equipment, plant, and new technical processes--fell from a 5.72% annual investment in 1965-69 to 3.23% between 1974 and 1979. Economic motivations and national tax policies will increase investments in automated equipment and robotics, and thus productivity should increase annually over the next decade. Sales of robotic devices were less than $100 million in 1980. Financial and industrial analysts

Annual percentage change in United States non-farm business productivity

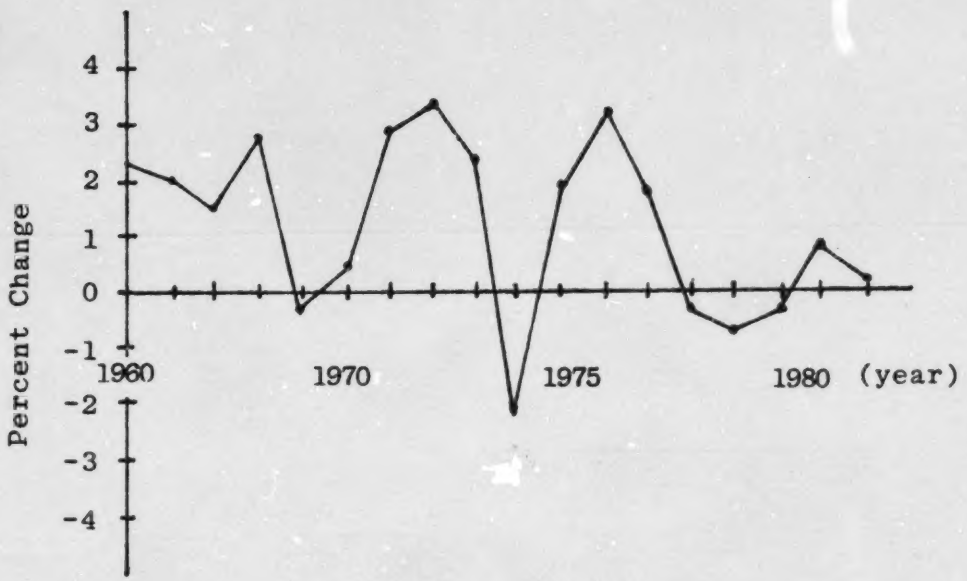

Figure 1. Non-farm business productivity percentage change from previous year in output per hour. Data from Economic Report of the President, 1982, U.S. Department of Labor, Bureau of Labor Statistics. (Note 1)

estimate geometric increases in sales--$350 million by 1984 and the annual potential for $2 billion by 1990 (Conigliaro, Note 2). Even substantially less growth will cause major structural changes in white-collar and blue-collar labor markets. With a business growth national tax policy, these estimates may be on the conservative side by a multiple of two or three.

Japan, which has a greater number of robots in place and a historical base upon which to make projections, estimates rapidly increasing investments and aggregate demand for robots in manufacturing and non-manufacturing (Figure 2). Japan's investment in robotics, which began in the early '70s, will increase to $312 million by 1980. It is expected to grow to $2.4 billion in 1990 and $4 billion by the year 2000.

Insert Figure 2 about here

The introduction of robots into the Japanese economy has been successful because of a depleted labor market. The casualties of World War II left Japan with a 1,800,000 shortage of skilled workers in 1965. Robots were introduced not to do the unskilled, drudgery work, but the work of a skilled work force (Japan Industrial Robot Association, p.4). Further usage of robots has been accelerated in response to

1) higher-aged labor force in the manufacturing field,

2) shortages of technical personnel,

3) movement of labor force into tertiary (white collar)

Estimated growth of investments in industrial robots in Japan

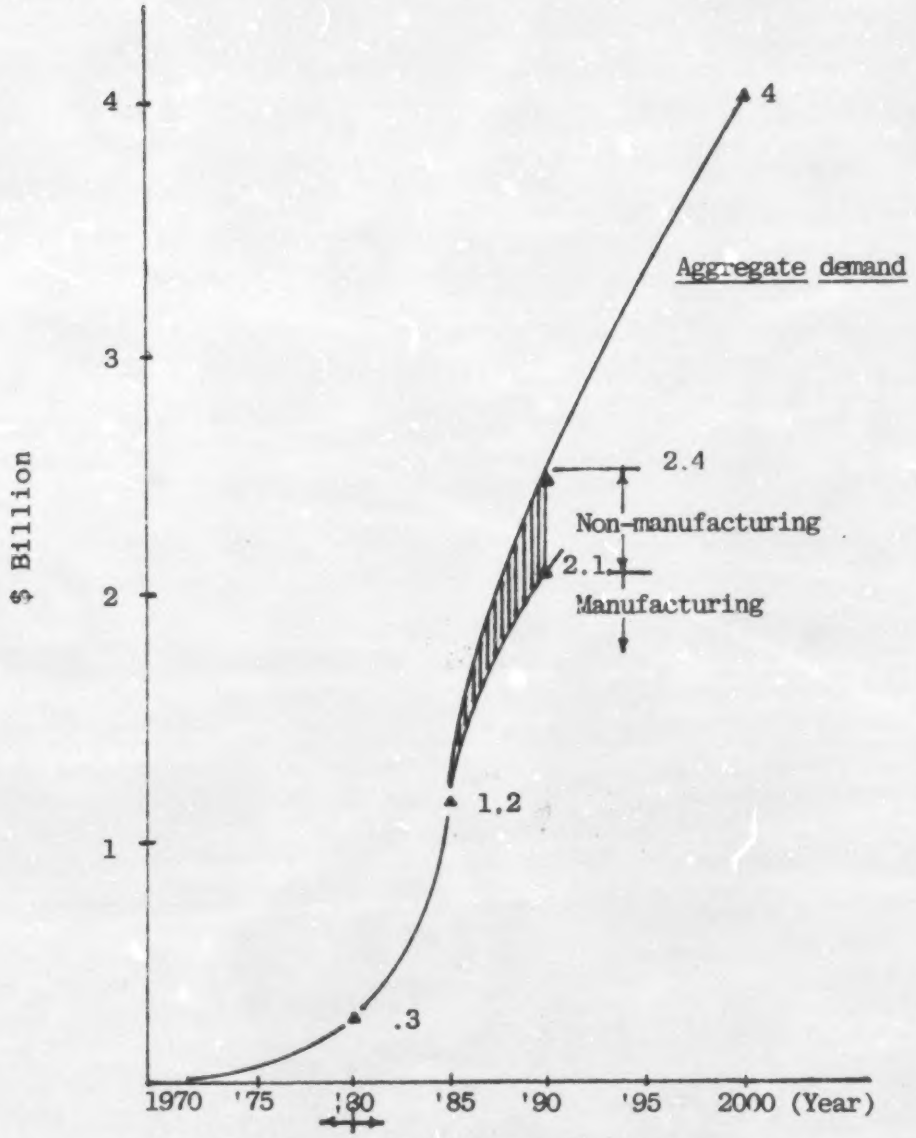

Figure 2. Aggregate demand for industrial robots both in manufacturing and non-manufacturing fields. (The Japan Industrial Association, 1982)

industries as a result of higher education and higher living standards, and

4) consistent efforts to improve product quality and production technology (Japan Industrial Robot Association, p. i.),

Human Capital

The work force equivalent of war for Japan is the "pill" for the United States. The crest of the "baby boom" of the 1950s entered the labor force in 1975 (Figure 3). This wave has perpetrated "boom-bust" phenomena in the housing industry, baby food, and schools. The wave has had paradoxical impacts upon the economy and productivity. The young, inexperienced workers with low, underdeveloped skills result in a lower per capita productivity, a glut of unemployment, and complaints from industries that young people are not "work-ready".

Insert Figure 3 about here

As shown in Figure 3, a decreasing percentage of new workers--ages 18-24--will be entering the labor market. The glut of labor will turn into a scarce commodity, and the national economy will be forced to invest more per capita in physical and human capital. Large investments in human capital for further education and training will be made by business, industry, and government.

"Baby-boom" wave crest entering the labor market

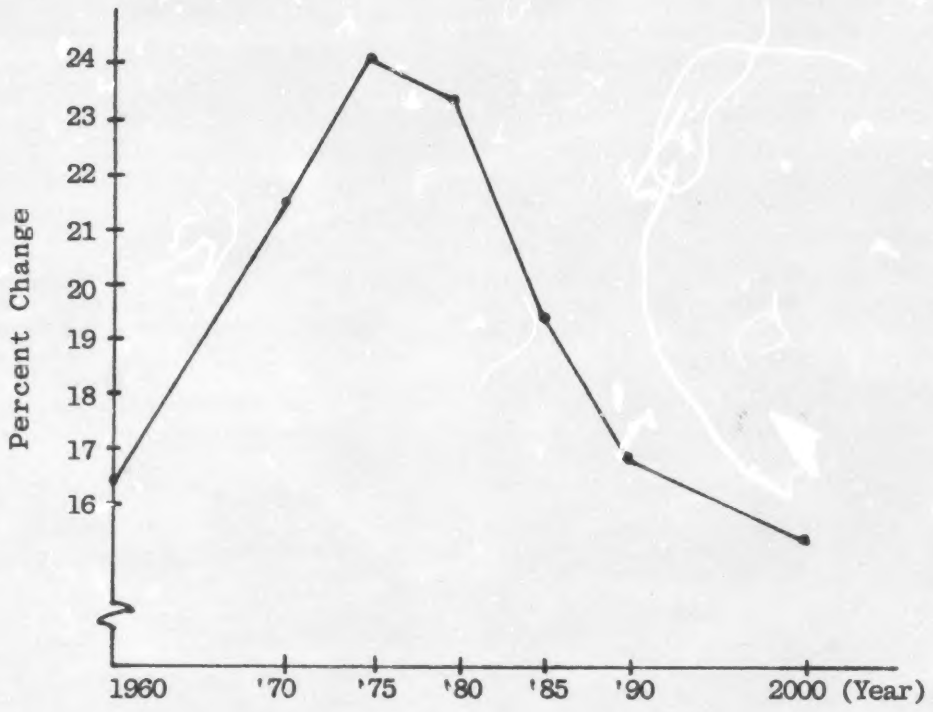

Figure 3. Indicator of entry-labor-force potential, the 18-24 age cohort as a percentage of the total 18-65-year old labor force potential. Data from Statistical Abstract of the United States, Department of Commerce, Bureau of the Census, 1979. (Note 3).

Generating Human and Physical Capital

The path facing higher education and industry is difficult and uncharted. The decision making engaged in by both sectors should be coordinated: what trade-offs will be made between the cost of physical capital investment and human capital investment? What will be the training domain of the college and the corporation?

Economist Jacob Mincer (1962) and Gary Becker (1964) offer the best analyses of investments in human capital from the perspectives of formal schooling and on-the-job training. Schooling and training are further differentiated between "general" and "specific". Within an era of rapid technological change, the worker must be made adaptable. Adaptability tends to come from general types of training that are transferable from one firm to another, from one occupation to another. Machinists' skills are useful in many firms; writing skills are transferable from occupation to occupation. General education or general on-the-job training increases the future marginal productivity of the learner regardless of place of employment. Hence, general on-the-job training is normally paid for in part by the employee (the intern, the writer, the apprentice machinist, etc.) by accepting wages or salaries below their current opportunity wage level (Becker, p.13). The college student pays for general training through tuition and fees and opportunity costs (the income foregone in order to attend school rather than to work for wages or salary).

Specific training, on the other hand, increases the em-

ployee's marginal productivity and that of the firm providing the training. The skills are not normally transferable to another firm. The willingness of either firm or employee paying for firm-specific training depends on expected worker turnover. If the job skill is transient because of expected technological change, the worker is less likely to share in the training costs; if the worker is perceived as transient by the firm, the firm is less likely to invest in specific or general training.

The accepted economic ground rules of investments in human capital have been changing. Business and industry no longer restrict their investments to "job specific" programs. Because traditional education in colleges and universities has not provided an adequate stock of literate, analytically competent graduates, or graduates with on-the-job adaptability without additional schooling, corporations have begun to fill the need.

In a recent estimate, the American Society of Training and Development found that industry annually invested $30-40 billion in educating its employees. This investment is about one-half of the total investment made in U.S. colleges and universities (Watkins, 1983). Even if colleges and universities could recapture their supremacy in general education, rapid changes caused by new technologies would continue to compel corporations to fill the gap in technologically advancing programs. This growth is a reflection of the perceived failure of American higher education.

Corporate "colleges" and "universities" are now offering Ph.D. programs for their employees and tuition-paying outsiders. The distinction between general and specific on-the-job training

has become hazy. Whereas teaching such basics as reading, writing, and mathematics were once the preserve of the high schools and colleges, business has been compelled to upgrade the basic skills of their workers so they--business and the worker--can function effectively.

The costs of education incurred by business will be more than offset by increasing productivity and more cost-effective technologies. The key to cost-effective technologies is the highly flexible, efficient, and low-cost microprocessor and a correspondingly intellectual work force (Curley, 1982). Since the inventions of the integrated circuit and the development of the microprocessor, the technological world has undergone a revolution. This revolution makes in turn numerous new possibilities in manufacturing and non-manufacturing enterprises. The industrial robot, for example, becomes more flexible, efficient, and less costly than its earlier counterparts. At the same time, wages and salaries have increased significantly in the last ten years. In 1972, the introduction of a $150,000 robot might replace the effort of a $4.20 an hour assembly worker. Today a $150,000 robot may replace several $15-20 per hour workers. Firms now faced with greater educational costs will see relief in the productivity increase/cost savings of automation. An industrial robot or an office automation system may now pay for itself in two or three years of service.

Professionals, whether accountants, engineers, or medical doctors, will be faced with "intellectual technologies". The

engineer's productivity will be abetted by computer assisted design/computer assisted manufacturing (CAD/CAM) technologies; the physician by high technology diagnostic equipment, and the accountant by computerized financial systems. In the next few years every profession will feel the impact of the microprocessor.

Higher Education--Planning for a Certain Future

In 1853 the United States Review prophesied that "machinery will perform all work....(t)he only task of the human race will be to make love, study, and be happy." The province of higher education is studying and happiness. If the aim of education is social betterment, then a worthwhile goal of higher education will be to prepare each graduate for study and growth and for self-fulfillment and happiness. The healthy skepticism of Emerson is recommended before we move headlong into specialized technical training at the expense of liberal education and generalizable intellectual skills.

Faced with a declining college-aged population (18-22), inflationary forces, and decreasing productivity, colleges and universities may react to the steel-collar revolution by a reckless plunge into specialized programs. The best hope for the human side of high technology--a side we will desperately need as a society and as individuals--will be a balanced educational philosophy.

The education of the 1980s, 1990s, and the twenty-first century must prepare the graduate for growth, adaptability, and further learning. Students must be prepared to be skilled in

analysis and problem solving. The newer technologies will require a higher level of verbal and mathematical literacy to work in the processing of information. Higher education for the future should contain essential elements for on-the-job scientific and technical training.

What may be overlooked in the preparation of a post-industrial society is the need for balance--for an education to stimulate human concerns and human values. We will live in a smaller, interdependent world where the greatest (and scarcest) attributes may be to work harmoniously and productively and to be self fulfilled as a whole person.

Higher education may have become too compartmentalized to survive future competition and challenge. Students may have become less venturesome and reluctant to select a powerful literary/scientific/humanistic education--but such an education may be the form needed to face technological change with confidence and composure.

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Reference Notes

1. This figure is based upon Table B-40, productivity and related data, private business sector. Percentage change for 1982 versus 1981 is based upon recently released Bureau of Labor Statistics data.
2. Investment estimates derived from unpublished institutional research reports prepared by Bache, Halsey, Stuart, Shields, Inc., Laura Conigliaro author. Nov. 1980 - March 1983.
3. This figure is based upon data in Table Number 5, "Estimated and Projected Population." 18-24 year olds as a percentage of 18-64 year olds using type II mid-range estimate projections.